# PIXEL MODULE YIELD ESTIMATES


### *M. G. D. Gilchriese*

### *LAWRENCE BERKELEY NATIONAL LABORATORY*


### *February 1, 1999*

## *INTRODUCTION*

The purpose of this note is to provide a framework for the estimate of the assembly yield of pixel modules. It must be emphasized that the actual values of the losses at each step of the module assembly process are not well known at this time. However, the spreadsheets and other information contained in this note are intended to provide a framework to systematically capture this information as it becomes available.

The overall yield to produce a pixel module may be broken into four basic steps

1. Front-end electronics yield, including all fabrication, probing, bumping, thinning, metallization and dicing
2. Detector yield including all fabrication, probing, bumping
3. Flex hybrid or MCM-D interconnect steps including fabrication, probing, cutting
4. Module assembly including flip-chip mating, probing, attachment of interconnects, other component attachment, etc

Each of these basic steps is further broken down into individual steps in the sections below. The spreadsheet at the end of the document provides a means to summarize the information. The values given in the spreadsheet are my current estimates but must be validated by prototype construction and other means. The reader is free to make his/her own assumptions.

This note assumes the reader is familiar with the general steps necessary to assemble a pixel module.

## *ELECTRONICS YIELD*

This applies to the yield of the front-end chips. The steps are given below.

1. Manufacturer fabricates six inch wafers.
2. Wafers are shipped to sites for probing.
3. Wafers are probed at these sites and marked.
4. Probed wafers are sent to bump deposition vendors.This assumes thinning and metallization are done after bumping. We do not now know if this is possible. The alternative would be to thin and metallize before bump deposition. We don't know if this is possible either.
5. Bumps are deposited.
6. Bumped wafers are sent to sites for visual or other inspection. It's possible this could be done at the bumping vendor, in which case a shipping step is eliminated.
7. Wafers are inspected
8. The bumped wafers are then sent to vendors for thinning and backside metallization. If this is two vendors(the current case) another shipment step needs to be added.
9. Wafers are thinned and metallized.
10. The thinned and metallized wafers are then sent to be diced. Note we have not assumed an additional inspection step before this that may be necessary.
11. The wafers are diced.

12. The die are sorted. It is assumed this is done at the same place as dicing, but it may be necessary to do this at another vendor or at institutes, in which case another shipment step would be added.
13. Sorted die are shipped to the location for flip-chip assembly.
14. The sorted die are inspected at this location. It's possible that the die might be inspected elsewhere, in which case another shipment step would be needed.

## *DETECTOR YIELD*

This applies to the yield of detector tiles. The steps are given below.

1. The detectors are fabricated in four inch wafers. In the spreadsheet, I have assumed that the manufacturer delivers only "good" detectors but this may not be the case.
2. Wafers are shipped to sites for probing.
3. Wafers are probed and good detectors marked.
4. Wafers are shipped to bump deposition vendors.
5. Bumps are deposited.
6. Bumped wafers are shipped to sites for visual or other inspection. This might be done at the bumping vendor, in which case a shipment step is eliminated.
7. The bumped wafers are sent to the dicing vendors. It may be that dicing is done by the bumping vendor.
8. The wafers are diced.
9. The tiles are sorted. This assumes sorting done at the dicer, which may not be correct.
10. The sorted tiles are sent to the flip-chip vendor.
11. The sorted tiles are inspected at the flip-chip vendor. It's possible this might be done at an institute, in which case another shipment step should be added.

## *FLEX HYBRID YIELD*

This applies to the yield of assembled flex hybrids before they are attached to the bare modules(defined as 16 die flip-chipped to a tile). This furthermore assumes all components on the flex hybrid are attached before attaching the flex-hybrid-assembly to the bare module. The steps are given below.

1. The flex hybrids are fabricated. We don't know if the vendor will deliver cut, tested parts or if cutting and testing will be done by others. The spreadsheet is set up for this possibility.
2. The hybrids are inspected visually.
3. The flex frames are shipped to be cut.
4. The flex are cut from the frames.
5. The cut parts are shipped to be probed and marked.
6. The probed parts are shipped to the sites for component assembly.
7. Components are mounted. This assumes only surface mount components are mounted in a company or companies. This may be done in institutes, in which case some shipping can be eliminated.
8. Flex hybrids with components are shipped to the module assembly sites or to institutes for wire bonding.
9. Wire bonding and other specialized mounting is done in institutes.
10. It is assumed that they are retested/probed at and this may include some burn-in of the MCC. It has not been shown that this is practical.
11. The completed and tested flex hybrid assemblies are shipped to module assembly sites.

## *MODULE ASSEMBLY*

Module assembly includes flip-chip assembly to produce a bare, 16-chip module, probing of this module, attachment of the assembled flex hybrid, attachment of fibers and power, testing and related shipping. The steps are given below.

1. Flip-chip die to tiles.
2. The bare module yield is calculated from the individual die yield to the $16^{th}$ power.

3. The bare modules are shipped.
4. The bare modules are inspected(X-ray inspection). I remains to be shown that this step is needed.
5. The inspected modules are shipped to module assembly sites.
6. The bare modules are probed. At a minimum, digital functionality for each die is tested. It remains to be shown that full analog functionality with a biased detector is feasible. It's assumed the probing is not done at a module assembly site. If it is, a shipping step could be eliminated.
7. The probed modules are shipped to the module assembly sites.
8. The flex hybrid is attached.
9. Wire bonding is done. This includes also repair.
10. The power and optics connections are attached.
11. The module is tested and burn-in occurs.
12. The tested modules are shipped to the sites for assembly on sectors or staves.

## *SPREADSHEET*

A spreadsheet template with initial guesses for yields is part of this document below.

Pixel Module Yield Model
Last Update: February 1, 1999

| ICs Yield(%) | ICs Step | Detectors Yield(%) | Detectors Step | Flex Yield(%) | Flex Step |
|---|---|---|---|---|---|
| 30.0% | Fab | 100.0% | Fab | 80.0% | Fab |
| 99.5% | Ship | 99.5% | Ship | 100.0% | Inspect(in fab) |
| 97.0% | Probe | 90.0% | Probe | 100.0% | Ship |
| 99.5% | Ship | 99.5% | Ship | 100.0% | Cut(in fab) |
| 97.0% | Bump deposition | 97.0% | Bump deposition | 100.0% | Ship |
| 99.5% | Ship | 99.5% | Ship | 100.0% | Probe(in fab) |
| 99.5% | Inspection(bump yield) | 92.3% | Inspection(bump yield) | 99.5% | Ship |
| 99.5% | Ship | 99.5% | Ship | 95.0% | Mount components |
| 95.0% | Thin and metallize | 97.0% | Dice | 99.5% | Ship |
| 99.5% | Ship | 99.0% | Sort | 97.0% | Wire bond |
| 97.0% | Dice | 99.5% | Ship | 97.0% | Probe/burn-in |
| 97.0% | Sort | 99.0% | Inspect | 99.5% | Ship |
| 99.5% | Ship | | | | |
| 99.0% | Inspect | | | | |
| Yield(%) | 24% per die | | 75% per tile | | 70% per flex |

| Yield(%) | Module Assembly |
|---|---|
| 99.0% | Flip chip/die |
| 85.1% | Flip chip/module |
| 99.5% | Ship |
| 99.0% | Inspect |
| 99.5% | Ship |
| 99.0% | Probe bare module |
| 99.5% | Ship |
| 98.0% | Attach flex |
| 95.0% | Wire bond(with repair) |
| 98.0% | Attach pwr/optics |
| 99.5% | Ship |
| 95.0% | Test/burn in |
| 99.5% | Ship |
| | 70% per module |

99.5% Shipping yield